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(54) **METHOD AND SYSTEM FOR MECHANICAL COUPLING OF FLEXIBLE PRINTED CIRCUIT TO A SENSOR**

(75) Inventor: **David Brent Guard**, Hampshire (GB)

(73) Assignee: **Atmel Corporation**, San Jose, CA (US)

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(51) **Int. Cl.**

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G06F 3/044	(2006.01)
H01R 43/02	(2006.01)

(52) **U.S. Cl.**

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(58) **Field of Classification Search**

CPC H01L 2924/09701; H01L 2224/85201; H01L 24/05; H01L 24/06; B23K 20/10; B23K 2201/42; G06F 3/044; G06F 3/0412; G06F 3/03547; G06F 3/0414; G06F 3/046; G06F 1/1626; G06F 3/045; H03K 17/962; H03K 2217/960755; H03K 2217/96023; H03K 2217/96031; F16L 47/03

USPC 345/173–184

See application file for complete search history.

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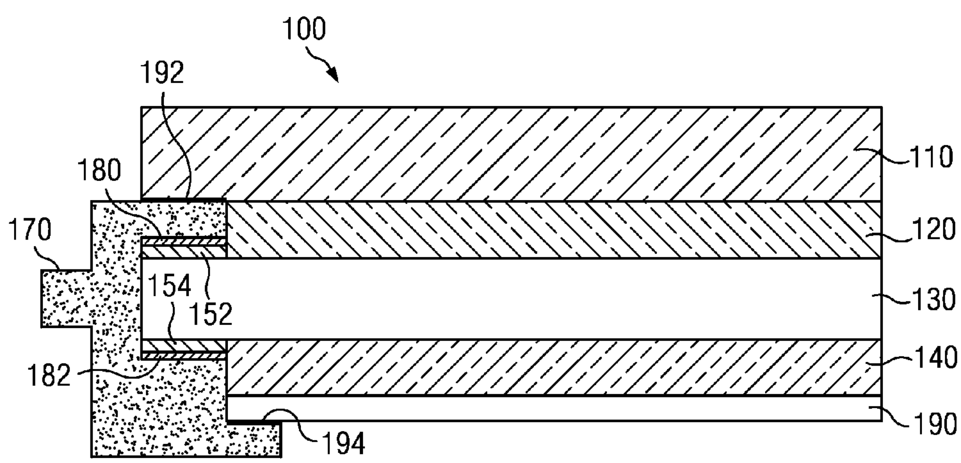
Primary Examiner — Amare Mengistu
Assistant Examiner — Gloryvid Figueroa-Gibson
(74) *Attorney, Agent, or Firm* — Baker Botts L.L.P.

(57) **ABSTRACT**

In one embodiment, a system includes a touch sensor comprising a set of electrodes and a set of one or more connection pads electrically coupled to the set of electrodes. The system also includes a circuit electrically coupled to the one or more connection pads such that signals may be communicated from the set of one or more connection pads to the circuit. The system further includes the circuit mechanically coupled to the touch sensor via friction welding.

18 Claims, 2 Drawing Sheets



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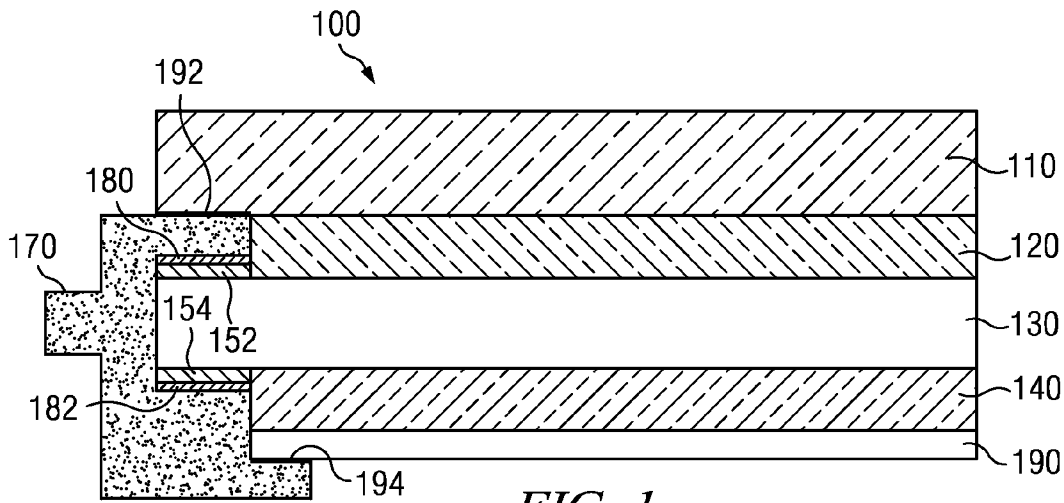
100
192
180
170
154
152
182
194
110
120
130
140
190

FIG. 1

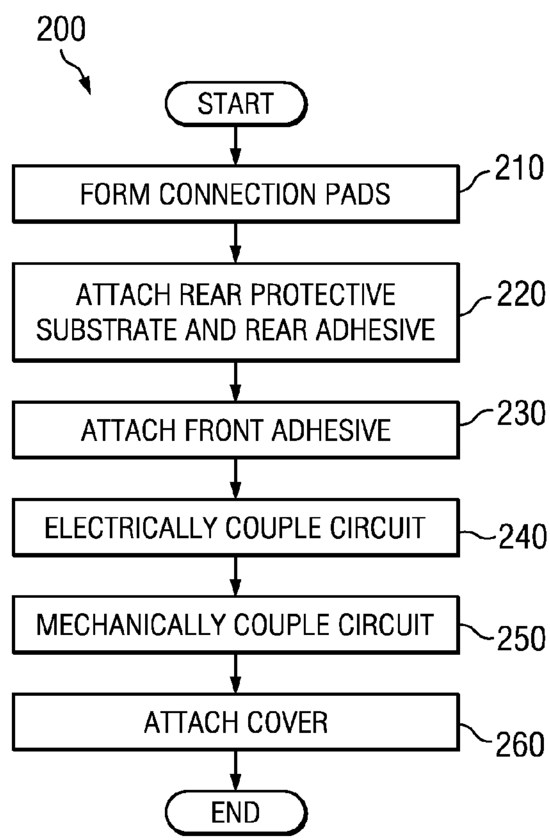
200
START
FORM CONNECTION PADS
210
ATTACH REAR PROTECTIVE SUBSTRATE AND REAR ADHESIVE
220
ATTACH FRONT ADHESIVE
230
ELECTRICALLY COUPLE CIRCUIT
240
MECHANICALLY COUPLE CIRCUIT
250
ATTACH COVER
260
END

FIG. 2

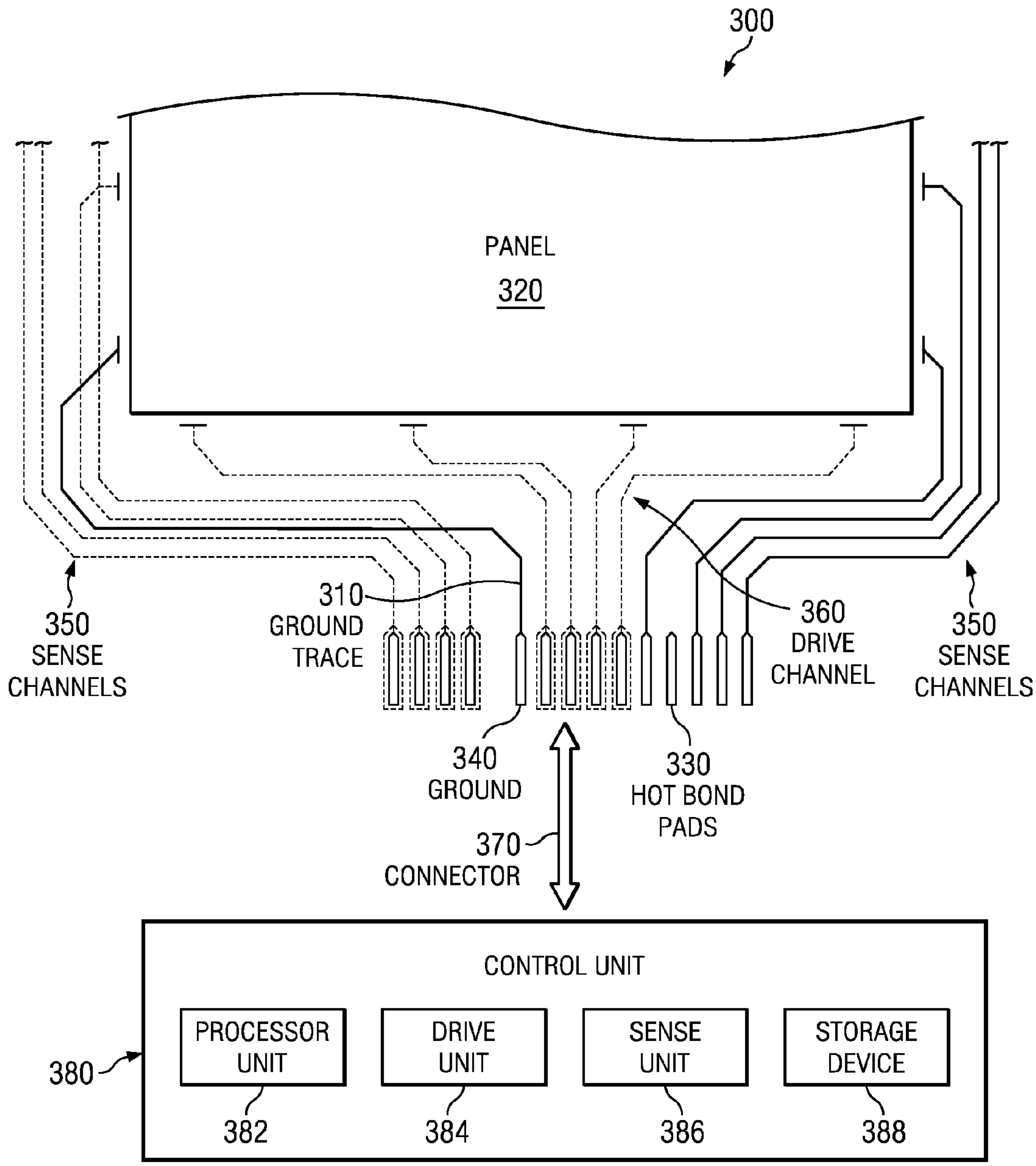
300
PANEL
320
310
GROUND
TRACE
350
SENSE
CHANNELS
360
DRIVE
CHANNEL
350
SENSE
CHANNELS
340
GROUND
330
HOT BOND
PADS
370
CONNECTOR
CONTROL UNIT
PROCESSOR
UNIT
DRIVE
UNIT
SENSE
UNIT
STORAGE
DEVICE
380
382
384
386
388

FIG. 3

METHOD AND SYSTEM FOR MECHANICAL COUPLING OF FLEXIBLE PRINTED CIRCUIT TO A SENSOR

BACKGROUND

A touch sensor may detect the presence and location of a touch or the proximity of an object (such as a user's finger or a stylus) within a touch-sensitive area of the touch sensor overlaid on a display screen, for example. In a touch sensitive display application, the touch sensor may enable a user to interact directly with what is displayed on the screen, rather than indirectly with a mouse or touch pad. A touch sensor may be attached to or provided as part of a desktop computer, laptop computer, tablet computer, personal digital assistant (PDA), smartphone, satellite navigation device, portable media player, portable game console, kiosk computer, point-of-sale device, or other suitable device. A control panel on a household or other appliance may include a touch sensor.

There are a number of different types of touch sensors, such as (for example) resistive touch screens, surface acoustic wave touch screens, and capacitive touch screens. Herein, reference to a touch sensor may encompass a touch screen, and vice versa, where appropriate. When an object touches or comes within proximity of the surface of the capacitive touch screen, a change in capacitance may occur within the touch screen at the location of the touch or proximity. A touch-sensor controller may process the change in capacitance to determine its position on the touch screen.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates one embodiment of a system used in a touch screen device;

FIG. **2** illustrates one embodiment of manufacturing a touch sensing system; and

FIG. **3** illustrates an example touch-screen system.

DESCRIPTION OF EXAMPLE EMBODIMENTS

FIG. **1** illustrates one embodiment of system **100** used in a touch-screen device. System **100** includes touch sensor **130**. Coupled to touch sensor **130** are connection pads **152** and **154**. Cover **110** is coupled to touch sensor **130** via adhesive **120**. Circuit **170** may be electrically coupled to connection pads **152** and **154** using connection pads **180** and **182**, respectively. In some embodiments, touch sensor **130** may be configured to detect touches (e.g., capacitively, the touches performed by one or more fingers or a stylus) on cover **110** and produce signals indicative of the detection. Connection pads **154** may be electrically coupled to aspects of touch sensor **130** (such as electrodes) that are aligned in one axis (e.g., the x-axis) and connection pads **152** may be electrically coupled to aspects of touch sensor **130** (such as electrodes) that are aligned in a different axis (e.g., the y-axis). In some embodiments, connection pads **154** may be capacitively coupled to connection pads **152** and may thereby receive signals from connection pads **152** and provide them to circuit **170**. System **100** may also include rear protective substrate **190** coupled to touch sensor **130** via adhesive **140**. Rear protective substrate **190** may provide structural strength to system **100** to prevent damage of system **100** and its various components.

In some embodiments, cover **110** may include material that allows for capacitive detection of touches on cover **110**. For example, cover **110** may be made of a resilient material suitable for repeated touching such as, e.g., glass, polycarbonate, or poly(methyl methacrylate) (PMMA). Cover **110** may be clear, opaque, or may have one or more levels of suitable opacities. As an example only and not by way of limitation, cover **110** may have a thickness of approximately 1 mm. This disclosure contemplates any suitable cover made of any suitable material.

In some embodiments, adhesives **120** and/or **140** may be formed of Optically Clear Adhesives (OCA). Adhesives that have other levels of opacities other than optically clear may be used to implement adhesives **120** and/or **140**. Adhesives **120** and **140** may be composed of suitable material (or combination of materials) that effectively attach touch sensor **130** to cover **110** and rear protective substrate **190**. As an example only and not by way of limitation, adhesives **120** and **140** may each have a thickness of approximately 0.05 mm.

In some embodiments, connection pads **180** and **182** of circuit **170** may be coupled to connection pads **152** and **154** using a film (not shown in FIG. **1**). Such film may be electrically conductive and may facilitate the adhering of connection pads **180** and **182** to connection pads **152** and **154**. As examples, such film may be implemented using Anisotropic Conduction Film (ACF) or anisotropic conduction paste (ACP).

In some embodiments, touch sensor **130** may include one or more electrodes that are configured to detect touches on the surface of cover **110**. Touch sensor **130** may be a single-sided touch sensor or a double-sided touch sensor, such as a double-sided FLM (fine line metal) touch sensor. For example, touch sensor **130** may be configured such that electrodes aligned in one axis (e.g., the y-axis) may be present on one surface of touch sensor **130** and electrodes aligned in a different axis (e.g., the x-axis) may be present on another surface of touch sensor **130**. As another example, touch sensor **130** may be configured such that electrodes aligned in one axis (e.g., the y-axis) may be present on the same surface of touch sensor **130** (e.g., the surface that faces cover **110**) as electrodes aligned in a different axis (e.g., the x-axis).

One or more portions of the substrate of touch sensor **130** may be made of polyethylene terephthalate (PET) or another suitable material. This disclosure contemplates any suitable substrate with any suitable portions made of any suitable material. In particular embodiments, the drive or sense electrodes in touch sensor **130** may be made of indium tin oxide (ITO) in whole or in part. In particular embodiments, the drive or sense electrodes in touch sensor **130** may be made of fine lines of metal or other conductive material. As an example and not by way of limitation, one or more portions of the conductive material may be copper or copper-based and have a thickness of between approximately 0.5 μm and approximately 5 μm width of between approximately 1 μm and approximately 10 μm. As another example, one or more portions of the conductive material may be silver or silver-based and similarly have a thickness of between approximately 0.5 μm and approximately 5 μm and a width of between approximately 1 μm and approximately 10 μm. This disclosure contemplates any suitable electrodes made of any suitable material.

An electrode (whether a drive electrode or a sense electrode) may be an area of conductive material forming a shape, such as for example a disc, square, rectangle, other suitable shape, or suitable combination of these. One or more cuts in one or more layers of conductive material may (at least in part) create the shape of an electrode, and the area of the shape may (at least in part) be bounded by those cuts. In particular embodiments, the conductive material of an electrode may occupy approximately 100% of the area of its shape. As an example and not by way of limitation, an electrode may be made of indium tin oxide (ITO) and the ITO of the electrode may occupy approximately 100% of the area of its shape, where appropriate. In particular embodiments, the conductive material of an electrode may occupy substantially less than 100% of the area of its shape. As an example and not by way of limitation, an electrode may be made of fine lines of metal or other conductive material (such as for example copper, silver, or a copper- or silver-based material) and the fine lines of conductive material may occupy substantially less than 100% of the area of its shape in a hatched, mesh, or other suitable pattern. Although this disclosure describes or illustrates particular electrodes made of particular conductive material forming particular shapes with particular fills having particular patterns, this disclosure contemplates any suitable electrodes made of any suitable conductive material forming any suitable shapes with any suitable fills having any suitable patterns. Where appropriate, the shapes of the electrodes (or other elements) of a touch sensor may constitute in whole or in part one or more macro-features of the touch sensor. One or more characteristics of the implementation of those shapes (such as, for example, the conductive materials, fills, or patterns within the shapes) may constitute in whole or in part one or more micro-features of the touch sensor. One or more macro-features of a touch sensor may determine one or more characteristics of its functionality, and one or more micro-features of the touch sensor may determine one or more optical features of the touch sensor, such as transmittance, refraction, or reflection.

Touch sensor **130** may implement a capacitive form of touch sensing. In a mutual-capacitance implementation, touch sensor **130** may include an array of drive and sense electrodes forming an array of capacitive nodes. A drive electrode and a sense electrode may form a capacitive node. The drive and sense electrodes forming the capacitive node may come near each other, but not make electrical contact with each other. Instead, the drive and sense electrodes may be capacitively coupled to each other through the dielectric material separating them. A pulsed or alternating voltage applied to the drive electrode may induce a charge on the sense electrode, and the amount of charge induced may be susceptible to external influence (such as a touch or the proximity of an object). When an object touches or comes within proximity of the capacitive node, a change in capacitance may occur at the capacitive node and a controller (not depicted in FIG. **1**) may measure the change in capacitance. By measuring changes in capacitance throughout the array, the controller may determine the position of the touch or proximity within the touch-sensitive area(s) of touch sensor **130**.

In a self-capacitance implementation, touch sensor **130** may include an array of electrodes of a single type that may each form a capacitive node. When an object touches or comes within proximity of the capacitive node, a change in self-capacitance may occur at the capacitive node and a controller may measure the change in capacitance, for example, as a change in the amount of charge needed to raise the voltage at the capacitive node by a pre-determined amount. As with a mutual-capacitance implementation, by measuring changes in capacitance throughout the array, the controller may determine the position of the touch or proximity within the touch-sensitive area(s) of touch sensor **130**. This disclosure contemplates any suitable form of capacitive touch sensing, where appropriate.

In particular embodiments, one or more drive electrodes may together form a drive line running horizontally or vertically or in any suitable orientation. Similarly, one or more sense electrodes may together form a sense line running horizontally or vertically or in any suitable orientation. In particular embodiments, drive lines may run substantially perpendicular to sense lines. Herein, reference to a drive line may encompass one or more drive electrodes making up the drive line, and vice versa, where appropriate. Similarly, reference to a sense line may encompass one or more sense electrodes making up the sense line, and vice versa, where appropriate.

Touch sensor **130** may have drive electrodes disposed in a pattern on one side of a substrate and sense electrodes disposed in a pattern on another side of the substrate or both the drive electrodes and the sense electrodes may be in patterns on the same side of touch sensor **130** (e.g., when touch sensor **130** is implemented as a single-sided touch sensor). An intersection of a drive electrode and a sense electrode may form a capacitive node. Such an intersection may be a location where the drive electrode and the sense electrode "cross" or come nearest each other in their respective planes. The drive and sense electrodes do not make electrical contact with each other—instead they are capacitively coupled to each other across a dielectric at the intersection. Although this disclosure describes particular configurations of particular electrodes forming particular nodes, this disclosure contemplates any suitable configuration of any suitable electrodes forming any suitable nodes.

In some embodiments, circuit **170** may be implemented using a flexible printed circuit. Any suitable set of materials and/or components may be used to implement circuit **170** that allows for the provision of signals to touch sensor **130** (via connection pads **152** and **154**) and the reception of signals from touch sensor **130** (via connection pads **152** and **154**). Circuit **170** may be coupled to other components, subsystems, or systems (not depicted in FIG. **1**) that may determine signals to be transmitted to touch sensor **130** and/or that may determine how signals received from touch sensor **130** are processed.

As described above, a change in capacitance at a capacitive node of touch sensor **130** may indicate a touch or proximity input at the position of the capacitive node. A controller may detect and process the change in capacitance to determine the presence and location of the touch or proximity input. The controller may then communicate information about the touch or proximity input to one or more other components (such one or more central processing units (CPUs) or digital signal processors (DSPs)) of a device that includes touch sensor **130**, which may respond to the touch or proximity input by initiating a function of the device (or an application running on the device) associated with it. Although this disclosure describes a particular controller having particular functionality with respect to a particular device and a particular touch sensor, this disclosure contemplates any suitable controller having any suitable functionality with respect to any suitable device and any suitable touch sensor.

In some embodiments, tracks of conductive material disposed on the substrate of touch sensor **130** may couple the drive or sense electrodes of touch sensor **130** to connection pads **152** and **154**, also disposed on the substrate of touch sensor **130**. Tracks may extend into or around (e.g. at the edges of) the touch-sensitive area(s) of touch sensor **130**. Particular tracks may provide drive connections for coupling circuit **170** to drive electrodes of touch sensor **130**, through which circuit **170** may supply drive signals to the drive electrodes. Other tracks may provide sense connections for coupling circuit **170** to sense electrodes of touch sensor **130**, through which charge at the capacitive nodes of touch sensor **130** may be sensed. Tracks may be made of fine lines of metal or other conductive material. As an example and not by way of limitation, the conductive material of tracks may be copper or copper-based and have a width of between approximately 10 μm and 100 μm. As another example, the conductive material of tracks may be silver or silver-based and have a width of between approximately 10 μm and 100 μm. In particular embodiments, tracks may be made of ITO in whole or in part in addition or as an alternative to fine lines of metal or other conductive material. Although this disclosure describes particular tracks made of particular materials with particular widths, this disclosure contemplates any suitable tracks made of any suitable materials with any suitable widths. In addition to tracks, touch sensor **130** may include one or more ground lines terminating at a ground connector (which may be a connection pad) at an edge of the substrate of touch sensor **130** (similar to the tracks described above). In some embodiments, connection pads **152** and **154** may be implemented using conductive material, such as copper and may be located along one or more edges of the substrate, outside the touch-sensitive area(s) of touch sensor **130**. Connection pads **152** and **154** may be implemented as tracks.

One or more portions of the substrate of rear protective substrate **190** may be made of polyethylene terephthalate (PET) or another suitable material. This disclosure contemplates any suitable substrate with any suitable portions made of any suitable material.

As shown in FIG. **1**, circuit **170** may be mechanically coupled to touch sensor **130**. In some embodiments, circuit **170** may be mechanically coupled to touch sensor **130** via friction welding and/or another localized welding technique. As is known in the art, friction welding is a class of solid-state welding processes that generates heat through mechanical friction between a moving workpiece and a stationary component, with the addition of a lateral force called "upset" to plastically displace and fuse the materials. For example, as seen in FIG. **1**, portions of circuit **170** not having connection pads **180** and **182** and/or other electrical components (e.g., traces and/or electrodes) formed thereupon may be friction welded to portions of touch sensor **130** not having connection pads **152** and **154** formed and/or other electrical components (e.g., traces and/or electrodes) thereupon. Circuit **170** may further be coupled to cover **110** via friction welding (e.g., as shown by friction weld **192** in FIG. **1**), another localized welding technique, adhesive **120**, or other suitable manner providing additional structural strength for components of system **100**. If circuit **170** is friction welded to cover **110**, cover **110** may be made of a material suitable for friction welding, such as polycarbonate, PMMA, or any suitable clear, hard, polymer compounds. In these and other embodiments, circuit **170** may also be coupled to rear protective substrate **190** via friction welding (e.g., as shown by friction weld **194** in FIG. **1**), another localized welding technique, adhesive **140**, or other suitable manner, which may also provide additional structural strength for components of system **100**. Such use of friction welding or another localized welding technique to couple circuit **170** to sensor **130** may increase adhesion of circuit **170** as compared with traditional approaches (e.g., coupling of circuit **170** to touch sensor **130** via an adhesive such as adhesive **140** or via a conductive film, for example), thus increasing an effective peel strength of an FPC assembly. Furthermore, in single-sided designs in which connection pads and electrodes are disposed on only one side of touch sensor **130** (in which the connection pad area is generally unsupported and relatively thin in profile), such friction welding or other localized welding of circuit **170** to touch sensor **130** provides additional structural strength for system **100** as compared to traditional approaches. In some embodiments, friction welding may be used to mechanically bond components of system **100** at optically opaque portions of system **100**.

FIG. **2** illustrates one embodiment of manufacturing a touch sensing system. In general, the steps illustrated in FIG. **2** may be combined, modified, or deleted where appropriate, and additional steps may also be added to the example operation. Furthermore, the described steps may be performed in any suitable order. In some embodiments, the steps described below may be performed by any suitable combination of the elements discussed above with respect to FIG. **1**.

The method may start at step **210**, where, in some embodiments, connection pads may be formed on a touch sensor. The touch sensor may include electrodes that are configured to detect touches on a cover that is near the touch sensor. Each connection pad may be formed in FLM or printed in silver such that electrodes of the touch sensor may be coupled to one or more components that process signals received from the electrodes or provide signals to the electrodes. The touch sensor may have electrodes on more than one side of the touch sensor and connection pads may be formed on more than one side of the touch sensor. As an example, this step may be used to form connection pads **152** and **154** on touch sensor **130** of FIG. **1**.

At step **220**, in some embodiments, a circuit may be electrically coupled to at least some of the connection pads coupled at step **210**. Examples of circuits that may be coupled at this step are given above with respect to circuit **170** of FIG. **1**. At this step, in some embodiments, the circuit may only be arranged on one side of the touch sensor. For example, the circuit may only be directly coupled to connection pads that are located on one side of the touch sensor. The circuit may be coupled using anisotropic conduction film bonding.

At step **230**, the circuit may be mechanically coupled to the touch sensor via friction welding another localized welding technique, or similar technique. This step may be performed before, during, or after step **220**. For example, portions of the circuit not having connection pads and/or other electrical components (e.g., traces and/or electrodes) formed thereon may be friction welded to portions of the touch sensor not having connection pads and/or other electrical components (e.g., traces and/or electrodes) formed thereon.

At step **240**, in some embodiments, a cover may be attached. Examples of covers may be attached at step are given above with respect to cover **110** of FIG. **1**. A cover may be attached using an adhesive to the touch sensor and/or attached to the circuit using an adhesive, friction welding, another localized welding technique, or other suitable approach. Examples of adhesives that may be used at step are given above with respect to adhesive **120** of FIG. **1**. The cover attached at this step may be the element that receives touches such as for example, a glass or plastic face of a touch input device (e.g., a phone, tablet, or instrument panel). In-mold lamination (IML) may be used at this step to form the cover. In some embodiments, having the touch sensor coupled to the circuit on the surface opposite to the surface that interfaces with the cover may result in less expensive and faster manufacturing. For example, the surface of the touch sensor that interfaces with cover may be completely covered with optically clear adhesive without the need of cutouts in the adhesive because the circuit is not coupled to the touch sensor on this surface. This may also obviate any alignment procedures performed when making such cutouts in the adhesive and laminating to the touch sensor.

At step **250**, in some embodiments, a rear protective substrate may be attached. Examples of rear protective substrates may be attached at step are given above with respect to rear protective substrate **190** of FIG. **1**. A rear protective substrate may be attached using an adhesive to the touch sensor and/or attached to the circuit using an adhesive, friction welding, another localized welding technique, or other suitable approach. Examples of adhesives that may be used at step are given above with respect to adhesive **140** of FIG. **1**.

At step **260**, in some embodiments, a controller may be coupled to the circuit attached at step **220**, at which point the method may end. The controller may be configured to analyze signals generated by the touch sensor and/or may be configured to generate signals to be sent to the touch sensor. For example, the controller may send a drive signal to certain electrodes of the touch sensor and may analyze the signals received from electrodes that did not receive the drive signal to determine whether touch has occurred. Examples of the controller coupled at step **260** are discussed below with respect to control unit **380** of FIG. **3**.

The steps recited above with respect to FIG. **2** may be performed in any suitable order. For example, step **260** may occur before step **240** or step **250**. As another example, step **230** may occur before step **220**. As another example, certain aspects of step **230** may be performed at the same time as step **220**.

Furthermore, although this disclosure describes and illustrates particular components, devices, or systems carrying out particular steps of the method of FIG. **2**, this disclosure contemplates any suitable combination of any suitable components, devices, or systems carrying out any suitable steps of the method of FIG. **2**.

FIG. **3** illustrates an example touch-screen system **300**. System **300** includes touch sensitive panel **320** that is coupled to hot connection pads **330** and ground **340** using ground trace **310**, sense channels **350**, drive channels **360**. The drive and sense channels **350** and **360** are connected to a control unit **380** via a connector **370**. In the example, the traces forming the channels have hot connection pads **330**, to facilitate electrical connection via the connector **370**. As an example, control unit **380** may cause a drive signal to be sent to panel **320** via drive channel **360**. Signals detected in panel **320** may be sent to control unit **380** via sense channels **350**. As discussed further below, control unit **380** may process the signals to determine whether an object has contacted panel **320** or is in proximity to panel **320**. As depicted by the dotted lines in FIG. **3**, sense channels **350** may be formed within a different layer of touch-screen system **300** than that of drive channel **360** and ground trace **310**.

In particular embodiments, panel **320** may include a first layer of optically clear adhesive (OCA) beneath a cover panel. The cover panel may be clear and made of a resilient material suitable for repeated touching, such as for example glass, polycarbonate, or poly(methyl methacrylate) (PMMA). This disclosure contemplates any suitable cover panel made of any suitable material. The first layer of OCA may be disposed between the cover panel and the substrate with conductive material forming drive and sense electrodes. Panel **320** may also include a second layer of OCA and another substrate layer (which may be made of PET or another suitable material). The second layer of OCA may be disposed between the substrate with the conductive material making up the drive and sense electrodes and the other substrate layer, and the other substrate layer may be disposed between the second layer of OCA and an air gap to a display of a device including a touch sensor and a controller. As an example only and not by way of limitation, the cover panel may have a thickness of approximately 1 mm; the first layer of OCA may have a thickness of approximately 0.05 mm; the substrate with the conductive material forming the drive and sense electrodes may have a thickness of approximately 0.05 mm (including the conductive material forming the drive and sense electrodes); the second layer of OCA may have a thickness of approximately 0.05 mm; and the other layer of substrate disposed between the second layer of OCA and the air gap to the display may have a thickness of approximately 0.5 mm. Although this disclosure describes a particular number of particular layers made of particular materials and having particular thicknesses, this disclosure contemplates any suitable mechanical stack with any suitable number of any suitable layers made of any suitable materials and having any suitable thicknesses. In particular embodiments, panel **320** may be implemented using the embodiments disclosed above with respect to FIG. **1**.

In particular embodiments, control unit **380** may be one or more integrated circuits (ICs)—such as for example general-purpose microprocessors, microcontrollers, programmable logic devices or arrays, application-specific ICs (ASICs), tangible, non-transitory, computer-readable storage media—on a flexible printed circuit (FPC). Control unit **380** may include processor unit **382**, drive unit **384**, sense unit **386**, and storage device **388**. Drive unit **384** may supply drive signals to the drive electrodes of panel **320**. Control unit **380** may supply drive signals to the drive electrodes of panel **320**. Sense unit **386** may sense charge at the capacitive nodes included in panel **320** and provide measurement signals to processor unit **382** representing capacitances at the capacitive nodes. Processor unit **382** may control the supply of drive signals to the drive electrodes by drive unit **384** and process measurement signals from sense unit **386** to detect and process the presence and location of a touch or proximity input within the touch-sensitive area(s) of panel **320**. Processor unit **382** may also track changes in the position of a touch or proximity input within the touch-sensitive area(s) of panel **320**. Storage device **388** may store programming for execution by processor unit **382**, including programming for controlling drive unit **384** to supply drive signals to the drive electrodes, programming for processing measurement signals from sense unit **386**, and other suitable programming, where appropriate. Although this disclosure describes a particular control unit **380** having a particular implementation with particular components, this disclosure contemplates any suitable control unit having any suitable implementation with any suitable components.

Depending on the specific features implemented, particular embodiments may exhibit some, none, or all of the following technical advantages. Manufacturing of touch sensitive systems (e.g., touch screens) may be performed faster. Manufacturing of touch sensitive systems (e.g., touch screens) may be performed at a lower cost than conventional techniques. Increased yield may be realized during manufacturing. Tooling for manufacturing may become more simplified. Moisture ingress in touch sensitive systems (e.g., touch screens) may be reduced or eliminated. The reliability of an interface between a touch sensor and processing components may be enhanced. Other technical advantages will be readily apparent to one skilled in the art from the preceding figures and description as well as the proceeding claims. Particular embodiments may provide or include all the advantages disclosed, particular embodiments may provide or include only some of the advantages disclosed, and particular embodiments may provide none of the advantages disclosed.

Herein, reference to a computer-readable storage medium encompasses one or more non-transitory, tangible computer-readable storage media possessing structure. As an example and not by way of limitation, a computer-readable storage medium may include a semiconductor-based or other IC (such, as for example, a field-programmable gate array (FPGA) or an ASIC), a hard disk, an HDD, a hybrid hard drive (HHD), an optical disc, an optical disc drive (ODD), a magneto-optical disc, a magneto-optical drive, a floppy disk, a floppy disk drive (FDD), magnetic tape, a holographic storage medium, a solid-state drive (SSD), a RAM-drive, a SECURE DIGITAL card, a SECURE DIGITAL drive, or another suitable computer-readable storage medium or a combination of two or more of these, where appropriate. Herein, reference to a computer-readable storage medium excludes any medium that is not eligible for patent protection under 35 U.S.C. §101. Herein, reference to a computer-readable storage medium excludes transitory forms of signal transmission (such as a propagating electrical or electromagnetic signal per se) to the extent that they are not eligible for patent protection under 35 U.S.C. §101. A computer-readable non-transitory storage medium may be volatile, non-volatile, or a combination of volatile and non-volatile, where appropriate.

Herein, "or" is inclusive and not exclusive, unless expressly indicated otherwise or indicated otherwise by context. Therefore, herein, "A or B" means "A, B, or both," unless expressly indicated otherwise or indicated otherwise by context. Moreover, "and" is both joint and several, unless expressly indicated otherwise or indicated otherwise by context. Therefore, herein, "A and B" means "A and B, jointly or severally," unless expressly indicated otherwise or indicated otherwise by context.

This disclosure encompasses all changes, substitutions, variations, alterations, and modifications to the example embodiments herein that a person having ordinary skill in the art would comprehend. Moreover, reference in the appended claims to an apparatus or system or a component of an apparatus or system being adapted to, arranged to, capable of, configured to, enabled to, operable to, or operative to perform a particular function encompasses that apparatus, system, component, whether or not it or that particular function is activated, turned on, or unlocked, as long as that apparatus, system, or component is so adapted, arranged, capable, configured, enabled, operable, or operative.

What is claimed is:

1. A system comprising:

a touch sensor operable to determine a position of a touch within a touch-sensitive area of the touch sensor, the touch sensor comprising:

a non-touch-sensitive portion located along one or more edges of the touch sensor;

a first set of electrodes; and

a first set of one or more connection pads electrically coupled to the first set of electrodes and located on a first side of the touch sensor in the non-touch-sensitive portion; and

a circuit comprising a second set of one or more connection pads located on a first side of the circuit, wherein the circuit is:

a flexible printed circuit;

electrically coupled to the first set of one or more connection pads such that signals may be communicated from the first set of one or more connection pads to the circuit; and

mechanically coupled to the touch sensor via friction welding, wherein the mechanical coupling couples a portion of the first side of the touch sensor located between the first set of connection pads in the non-touch-sensitive portion to a portion of the first side of the circuit located between the second set of connection pads.

2. The system of claim **1** further comprising:

a second set of electrodes, the touch sensor comprising the second set of electrodes; and

a third set of one or more connection pads electrically coupled to the second set of electrodes and electrically coupled to the circuit.

3. The system of claim **2**, wherein:

the first set of electrodes and the first set of one or more connection pads are located on the first side of the touch sensor; and

the second set of electrodes and the third set of one or more connection pads are located on a second side of the touch sensor, the first side of the touch sensor and the second side of the touch sensor being located on different sides of a same substrate.

4. The system of claim **2**, wherein:

the first set of electrodes are arranged along a first axis; and

the second set of electrodes are arranged along a second axis, the first and second axes being substantially perpendicular to each other.

5. The system of claim **1**, wherein one or more portions of the first set of electrodes comprises indium tin oxide (ITO).

6. The system of claim **1**, wherein the circuit is mechanically coupled to the touch sensor via friction welding at portions of the touch sensor not having any connection pads, electrodes, and traces coupled thereto.

7. The system of claim **1**, further comprising a cover coupled to the touch sensor via an adhesive.

8. The system of claim **7**, further comprising the cover coupled to the circuit via friction welding.

9. The system of claim **7**, further comprising a rear protective substrate coupled to the touch sensor via a second adhesive and to the circuit via friction welding.

10. The system of claim **1**, the circuit mechanically coupled to the touch sensor via friction welding at optically opaque portions of the touch sensor.

11. A method comprising:

electrically coupling a first set of one or more connection pads to a first set of electrodes, a touch sensor comprising the first set of electrodes and the first set of one or more connection pads, the first set of one or more connection pads located on a first side of the touch sensor in non-touch-sensitive portion along one or more edges of the touch sensor;

electrically coupling a circuit to the first set of one or more connection pads such that signals may be communicated from the first set of one or more connection pads to the circuit;

mechanically coupling the circuit to the touch sensor via friction welding; and

wherein:

the circuit is a flexible printed circuit;

the circuit comprises a second set of one or more connection pads located on a first side of the flexible printed circuit; and

the mechanical coupling couples a portion of the first side of the touch sensor located between the first set of connection pads in the non-touch-sensitive portion to a portion of the first side of the circuit located between the second set of connection pads.

12. The method of claim **11** further comprising:

electrically coupling a third set of one or more connection pads to a second set of electrodes, the touch sensor comprising the second set of electrodes; and

electrically coupling the third set of one or more connection pads to the circuit.

13. The method of claim **12**, wherein:

electrically coupling the first set of one or more connection pads to the first set of electrodes comprises electrically coupling the first set of one or more connection pads to the first set of electrodes such that the first set of electrodes and the first set of one or more connection pads are located on the first side of the touch sensor; and

electrically coupling the third set of one or more connection pads to the second set of electrodes comprises electrically coupling the third set of one or more connection pads to the second set of electrodes such that the second set of electrodes and the third set of one or more connection pads are located on a second side of the touch sensor, the first side of the touch sensor and the second side of the touch sensor being located on different sides of a same substrate.

14. The method of claim **11**, wherein mechanically coupling the circuit to the touch sensor via friction welding comprising mechanically coupling the circuit to the touch sensor via friction welding at portions of the touch sensor not having any connection pads, electrodes, and traces coupled thereto.

15. The method of claim **11**, further comprising mechanically coupling a cover to the touch sensor via an adhesive.

16. The method of claim **15**, further comprising mechanically coupling the cover to the circuit via friction welding.

17. The method of claim **15**, further comprising mechanically coupling a protective substrate to the touch sensor via a second adhesive and to the circuit via friction welding.

18. The method of claim **11**, wherein mechanically coupling the circuit to the touch sensor via friction welding comprises mechanically coupling the circuit to the touch sensor at optically opaque portions of the touch sensor.

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